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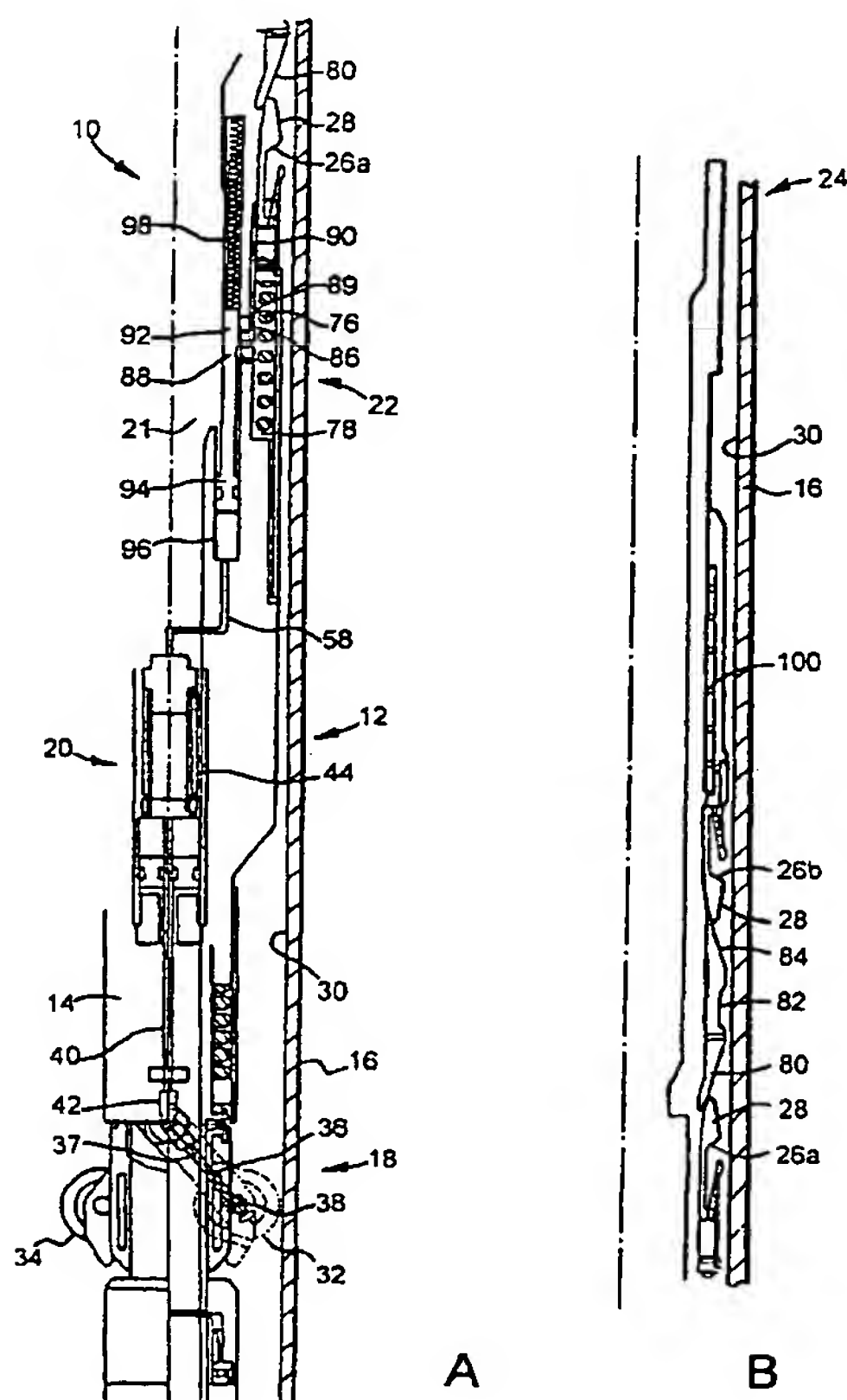
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(54) Title: **BRAKING DEVICE FOR TOOL STRINGS**



(57) Abstract: An embodiment of the invention discloses a restraint mechanism (12) of a braking device (10) for location in tubing (16) such as the casing of an oil or gas well. The braking device (10) forms part of a tool string which is run into the tubing (16) on a wireline and, in the event that the wireline breaks or is severed, the braking device (10) and the associated tool string falls through the tubing. The restraint mechanism (12) includes a sensor assembly (18), and a brake mechanism (22). The sensor assembly (18) senses the uncontrolled movement and provides an appropriate output causing activation of the brake mechanism (22), bringing the braking device (10) and tool string to a controlled stop.

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## BRAKING DEVICE FOR TOOL STRINGS

The present invention relates to a restraint mechanism, to a member having a restraint mechanism, and to a method of restraining a member, which member may be adapted to be located in tubing as utilised in a well such as an oil or gas well. In particular, but not exclusively, the present invention relates to a restraint mechanism for restraining a member adapted to be located in tubing, a member adapted to be located in well tubing and having a restraint mechanism, and to a method of restraining a member in well tubing from uncontrolled movement.

Well tools or secondary well tubing for location in the borehole of an oil or gas well are generally "run-in" to the borehole on an elongate support, such as wireline, coil tubing, a string of drill pipe, or the like. In offshore operations, the support will pass from the platform, rig or ship down through a marine riser, a wellhead assembly and into the borehole itself. In the event that the well tool is inadvertently released, or the support from which the well tool is suspended is released, separates or otherwise fails, the well tool falls through the riser and borehole until it encounters a restriction or obstruction, such as a closed safety valve.

Retrieval of such a tool typically involves a potentially complex, time-consuming and expensive "fishing"

operation. The well tool or tubing is then recovered to the surface for replacement or repair. Also, the safety valve or other obstruction encountered by the tool may have to be replaced or repaired.

5 It is amongst the objectives of embodiments of the present invention to obviate or mitigate at least one of the foregoing disadvantages.

According to a first aspect of the present invention, there is provided a restraint mechanism for restraining a member adapted to be moved axially through tubing, the  
10 restraint mechanism comprising:

a brake for selectively restraining the member in the tubing; and

brake activating means for activating the brake on  
15 sensing a condition indicative of uncontrolled movement of the member.

According to a second aspect of the present invention, there is provided a member adapted to be moved axially through tubing, the member having a restraint mechanism  
20 comprising:

a sensor for sensing uncontrolled movement of the member;

a brake adapted to be activated to engage the tubing to restrain the member therein; and

25 brake activating means for activating the brake on receipt of an output from the sensor indicative of

uncontrolled movement of the member.

These aspects of the invention provide a restraint mechanism for a member which will restrain the member, and any tools, devices or apparatus coupled to the member, in the event of uncontrolled movement such as may occur, for example, in the event of the member being inadvertently disconnected or otherwise released from a support, or in the event of a support string or wireline on which the member is supported being released, separating or otherwise failing. Thus, in such circumstances, in the presence of embodiments of the invention, the member will likely only drop a short distance, preventing or at least minimising damage to valves and other devices or fittings in the tubing, or the tubing itself, and may be retrieved from the tubing with relative ease.

Preferably, the member comprises an elongate body housing the brake and the brake activating means. The elongate body may further house the sensor. Alternatively, the member may comprise an elongate body, and the brake, brake activating means and sensor may be provided separately of the elongate body, and may be provided in the tubing in which the member is movable. Preferably, the member is adapted to be run through tubing such as a riser, or casing-lined borehole, or some other tubular form.

The sensor may be adapted to provide a continuous output as the member is moved within the tubing, and may

indicate uncontrolled movement of the member when the output reaches a predetermined threshold or value. Alternatively, the sensor may be adapted to only provide an output on the member experiencing uncontrolled movement, or  
5 the sensor detects or experiences a condition indicative of uncontrolled movement, for example that a support member, such as wireline, has been severed.

The sensor may comprise a mechanical sensor assembly. The mechanical sensor assembly may comprise a wheel or  
10 other member, adapted to engage an inner surface of the tubing and thus sense relative movement between the sensor and the tubing. The wheel may be biased into engagement with the tubing. Conveniently, the wheel is mounted on a spring-loaded arm to bias the wheel into engagement with  
15 the tubing.

The brake activating means may activate or release the brake in response to fluid pressure and one embodiment comprises a pump coupled to the mechanical sensor assembly. Conveniently, the pump is an axial flow pump, such as a  
20 wobble plate pump. The pump may be coupled to the mechanical sensor assembly by a pump drive shaft. Where the mechanical sensor assembly comprises a wheel, the wheel may be coupled to the pump drive shaft by a mitre gear assembly or other appropriate linkage. Conveniently, the  
25 pump drive shaft includes a universal joint, or other flexible link, which accommodates radial movement of the

wheel. The pump may have an outlet coupled to an arrangement for actuating or releasing the brake.

5 In this fashion, when the member is moved axially within the tubing, the wheel is rotated by contact with the inner surface of the tubing. This may in turn drive the pump via the mitre gear assembly, the universal joint and the pump drive shaft. This creates an increase in the pressure or flowrate of fluid at the pump outlet. Under normal operating conditions, during controlled movement of  
10 the member within the tubing, this pressure or flowrate is not sufficient to activate or release the brake. In the event of uncontrolled movement of the member, the wheel and pump rotate at higher rotational velocity, creating an increased pressure or flowrate at the pump outlet. On the  
15 pressure or flowrate reaching a predetermined threshold, the fluid at the pump outlet may activate or release the brake to engage the tubing and bring the member to a stop.

The pump may have a fluid conduit connected in a closed loop between the pump outlet and a pump inlet.  
20 Conveniently, the conduit has a restriction therein for restricting fluid flow in the conduit and, in use, maintaining fluid pressure higher at the outlet than at the inlet.

Conveniently, the pump further comprises a one-way  
25 valve coupled between the pump inlet and outlet, to avoid the pressure of the fluid at the outlet falling below the

pressure at the pump inlet, by permitting flow of fluid from the inlet to the outlet, when the brake is activated; activation of the brake may cause the pressure of the fluid at the pump outlet to fall below the fluid pressure at the inlet and in this situation the valve may open to prevent the creation of a partial vacuum at the pump outlet, which could hinder activation of the brake. Conveniently also, the pump includes a pressure compensator to compensate for variations in hydrostatic pressure as the member is moved through the tubing. The compensator may comprise a piston movably mounted on the pump drive shaft and having one face communicating with fluid in the tubing and the other face communicating with the pump inlet. The piston may exert a pressure on the pump fluid corresponding to the hydrostatic pressure in the tubing. Alternatively, the compensator may comprise a collapsible bellows coupled to the pump.

Preferably, the brake comprises a plurality of circumferentially disposed slips or slip fingers, and adapted to be moved to an extended position by an interaction with a cam, lever or other arrangement on the body. Conveniently, the brake further comprises a compression spring or other biasing arrangement for urging the slips to the extended position. The slips may be initially restrained in a retracted position by a latch or lock mechanism.

The brake lock mechanism may be fluid pressure

activated. The lock mechanism may comprise an axially movable annular piston, disposed in an annular chamber of a body in communication with the pump outlet. Preferably, the piston is axially movable with respect to the body, to selectively release the slips, and is preferably biased towards or otherwise releasably retained in a slip restraining position. The slips may be restrained in a retracted position by one or more radially movable locking keys disposed in the body. Conveniently, each key is disposed in a window of the body and is adapted to engage a profile of a portion of a slip, typically a sleeve or the like, to restrain the slips in the retracted position, the keys being maintained in the restraining position by a part of the piston. The profile and the key may be chamfered. When the pump outlet pressure reaches a predetermined level, due to uncontrolled movement of the member, the annular piston is moved axially, removing support for the keys and permitting disengagement of the keys from the slip sleeve. This releases the compression spring, forcing the slips to the extended position to engage the tubing and restrain the member against further uncontrolled movement.

Alternatively, the sensor may comprise an accelerometer for sensing the rate of change of velocity of the member. The restraint mechanism may further comprise a processor, coupled to the accelerometer, for

receiving data concerning the acceleration of the member. The processor may provide an appropriate output in the event that the member experiences uncontrolled movement, to activate the brake. Conveniently, the processor monitors  
5 the acceleration of the member over a sample time period to prevent spurious transient readings from causing a false brake activating output to be generated.

The brake activating means may comprise a solenoid latch, adapted to activate the brake on receipt of an  
10 appropriate output from the sensor. The solenoid latch may comprise a solenoid coil and a movable solenoid core. Conveniently, the solenoid coil and the solenoid core are disposed in an annular chamber in the body. The solenoid core may comprise an annular sleeve with the solenoid coil  
15 disposed around an outer surface thereof.

Conveniently, the latch or lock mechanism for the slips comprises the annular solenoid core, which core is axially movable within the annular chamber, to selectively release the slips. Preferably, the solenoid core is  
20 biased towards or otherwise releasably retained in a slip restraining position. The slips may be restrained in a retracted position by one or more radially movable locking keys disposed in the body. Conveniently, each key is  
25 disposed in a window of the body and is adapted to engage a profile of a portion of a slip, typically a sleeve or the like, to restrain the slips in the retracted position, the

keys being maintained in the restraining position by a part of the solenoid core. The profile and the key may be chamfered. In the event of an the senses an uncontrolled movement of the member, the microprocessor may provide a  
5 output to move the solenoid core axially, removing support for the keys and permitting disengagement of the keys from the slip sleeve. This releases the compression spring, forcing the slips to the extended position to engage the tubing and restrain the member against further uncontrolled  
10 movement. Elements of the mechanism, such as microprocessors, accelerometers or solenoid latches may be coupled to a source of electrical power disposed within the member. The power source may comprise a battery pack disposed in the body of the member. Alternatively,  
15 elements requiring a power input may be coupled to a source of electrical power at the surface by control\power cables.

In a further alternative embodiment, a sensor may comprise a flow or pressure sensitive element disposed in the body of the member for detecting fluid flow or pressure  
20 differentials resulting from movement of the member through fluid-filled tubing. The member may define a fluid passage through which fluid flows as the member is moved through the tubing, the passage containing a piston or other member which is responsive to fluid pressure to activate the  
25 brake. The passage preferably defines a flow restriction, such that the pressure differential across the piston is

flow-related, that is relates to the speed of descent of the member relative the fluid in the tube. The restriction may be incorporated in the piston. The flow restriction may be adjustable, to vary the brake activation threshold, and to account for, for example, differences in tubing fluid viscosities. The piston may be coupled to a cam or wedge to urge one or more slips to an extended position, or may release a latch or lock allowing the slips to extend. The slips may be biased towards a retracted configuration, or alternatively may be biased towards an extended configuration. The slips may define a ratchet arrangement to retain the extension of the slips, once the member slows or stops in the tubing and the flow-induced pressure differential across the piston falls. An element of the ratchet arrangement may be shearable or otherwise releasable, to allow the member to be retrieved. The ratchet arrangement may include a sacrificial element which may be the shearable element of the ratchet arrangement. The sacrificial element may comprise a locking ring and may be located between the cam or wedge and an inner sleeve of the member.

In a yet further alternative, the brake activating means may comprise one or more arms or other extendable members, and includes biasing means to activate the brake in the event of uncontrolled movement of the member. The biasing means may serve as a sensor for detecting a

condition indicative of uncontrolled movement of the member. Preferably, there are two arms, pivotably coupled to the member body by a common pivot. The arms may be pivotably coupled to each other in a scissors configuration, and may be movable between retracted and extended positions. Conveniently, the brake comprises a friction brake pad on each member. Each friction brake pad may be coupled to a first end of an arm. Conveniently also, the member body is adapted to be supported from a support member, such as wireline, coupled to the brake activating means, and the weight of the member and any associated tools, devices or apparatus, suspended via the brake activating means, retains the brake activating means in the retracted position. Preferably, the brake activating means comprises an axially movable activating member, coupled to the arms of the brake activating means, for moving the arms between the retracted and extended positions. The activating member may be directly or indirectly coupled at a first end to the support member and at a second end to the arms. Preferably, the activating member is disposed in a cylinder defined by a chamber in the member body. Preferably also, the biasing means comprises a spring disposed around the activating member. The member may include a radially outwardly extending shoulder. The biasing spring may be a compression spring, a first end of which may act against an annular end face of

the cylinder and a second end of which may act against the shoulder. In this fashion, the spring urges the activating member in an axial direction tending to move the arms to the extended position. Preferably, the weight of the member, and any tools devices and the like associated herewith, when coupled to the support member, compresses the biasing spring between the shoulder and the cylinder end face, to overcome a biasing force exerted by the biasing spring and retain the arms in the retracted position. However, in the event of an uncontrolled movement of the member due to, for example, severing of a supporting wireline, the biasing spring causes each arm of the restraint mechanism to extend outwardly to engage an inner surface of the tubing to slow and stop the member in the tubing. The brake activating means may include a damper to prevent transient shocks or accelerations of the member from activating the brake. Conveniently, the member defines a piston, the cylinder being oil filled to damp the transient shocks or accelerations.

According to a third aspect of the present invention, there is provided a member adapted to be suspended from a support member in tubing and be moved axially therein, the member have a restraint mechanism comprising:

a brake; and

brake activating means for activating the brake in the presence of a condition indicative of uncontrolled movement

of the member.

According to a fourth aspect of the present invention, there is provided a method of restraining a member from uncontrolled movement through tubing, the method comprising:

providing a brake; and

activating the brake to restrain the member when a condition indicative of uncontrolled movement of the member is experienced.

Preferably, the method further comprises the step of providing a sensor for sensing uncontrolled movement of the member, and the sensor being capable of generating a sensor output indicating an uncontrolled movement of the member; to activate the brake.

Embodiments of the present invention will now be described, by way of example, with reference to the accompanying drawings, in which:

Figure 1 is a longitudinal, partially sectioned view of a member having a restraint mechanism, in accordance with a preferred embodiment of the present invention;

Figure 2 is an enlarged, schematic view of a brake activating arrangement forming part of the restraint mechanism of Figure 1;

Figure 3A is a longitudinal, half-sectional view of part of a member having a restraint mechanism, in accordance with another embodiment of the present

invention;

Figures 3B and 3C are partial longitudinal, sectional views of the part of the member of Figure 3A, with the restraint mechanism shown in retracted and extended positions, respectively;

Figure 4 is a longitudinal, partially sectioned view of a member having a restraint mechanism, in accordance with an alternative embodiment of the present invention; and

Figures 5A and 5B are longitudinal, partially sectioned views of a member having a restraint mechanism, in accordance with a further alternative embodiment of the present invention, with a brake of the restraint mechanism shown in retracted and extended position, respectively.

Reference is made first to Figure 1, which is a longitudinal, partially sectioned view of a braking device 10, including a restraint mechanism 12 in accordance with a preferred embodiment of the present invention. The device 10 comprises an elongate body 14 which is adapted to be run into and through tubing 16, such as a marine riser and cased borehole, and on which tools or device may be mounted. The restraint mechanism 12 comprises a sensor and brake activating means in the form of a relative movement sensor assembly 18 coupled to a pump assembly 20 and latch 21, which control activation of a brake mechanism 22.

The device 10 is run into the borehole tubing 16 on

wireline or some other elongate support (not shown) which is coupled to an upper end of the body 14. The device 10 may form part of a tool string and be coupled to, or include, additional well tools, devices, or tubing.

5           On occasion, the wireline may break or be severed, in which case the unsupported device 10, and the associated tool string, drops through the tubing 16 in an uncontrolled fashion. It will be appreciated by persons skilled in the art that references herein to "uncontrolled" movement of  
10           the device 10 relate to movement of the device 10 which is not directly controlled by an operator, for example if the device 10 experiences "free fall" through the tubing.

          In this event, the relative movement sensor assembly 18 and the pump assembly 20, which is driven by the  
15           assembly 18, provides an output indicating that device 10 is experiencing uncontrolled movement and which activates the brake 22, as will be described in more detail below. On activation of the brake 22, slips 26a and 26b are released to move radially outwardly from a retracted  
20           position, as shown in Figure 1, to an extended position in which a grooved face 28 of each slip 26a, 26b engages an inner surface 30 of the tubing 16. This brings the device 10, and the associated tool string or tubing, to a controlled stop, and retains the device 10 at a fixed  
25           position in the tubing 16 until such time as the device 10 is retrieved to the surface. This is achieved by picking

up the tool, using a suitable fishing tool which engages the upper end 24 of the body 14. On jarring the device 10, the slips 26a and 26b disengage the tubing 16, as will be described in more detail below, thereby allowing the device 5 10 to pass up through the tubing 16 to the surface.

The restraint mechanism 12 comprises three wheels 32, 34 (only two shown) which are pivotally mounted to the tubular body 14 on spring-loaded arms, one of which is shown and given the reference numeral 36. The wheel 32 is 10 biased by the spring-loaded arm 36 into engagement with the inner surface 30 of the casing 16, and the wheel 32, which typically carries a tyre of an elastomeric material, rotates as the member 10 is moved axially through the casing 16. The wheel 32 is coupled to a shaft 37 extending 15 through the arm 36 by a mitre gear assembly 38, which comprises two bevel gears having cone angles of  $45^\circ$  each disposed at  $90^\circ$  with respect to one another, one coupled to the hub of the wheel 32, and the other coupled to the end of the shaft 37. Furthermore, the shaft 37 is coupled to 20 a drive shaft 40 of the pump assembly 22 through a universal joint 42; the universal joint 42 accommodates pivoting of the arm 36. The rotation of the shaft 40 drives an axial flow pump 44, in the form of a wobble plate pump.

25 Referring now also to Figure 2 of the drawings, which is an enlarged, schematic view of the pump assembly 20 of

Figure 1, it will be seen that the pump 44 is disposed in a chamber 46 of the tubular body 14, and that the pump drive shaft 40 extends through an opening in a wall 48 of the chamber 46, provided with a rotary seal 50, which prevents egress of fluid from a plenum chamber 52 filled with the pump fluid. The pump 44 has a fluid inlet 54 in connection with the chamber 52 and a fluid outlet 56 which communicates with an outlet conduit 58 leading to the brake mechanism 22. Also, a feedback conduit 60 is coupled between the pump outlet 56 and the chamber 52, to recycle fluid passing through the pump 44 in a closed-loop. The feedback conduit 60 includes a restriction orifice 62, which provides a restriction to fluid flow through the conduit 60. The pressure of the pump fluid at the pump outlet 56 is thus maintained, during controlled movement of the member 10 within the tubing 16, above the pressure of the fluid at the pump inlet 54, as a pressure differential is created across the restriction orifice 62.

Furthermore, a one-way valve 64 is provided in a further conduit 66 between the outlet 56 and inlet 54. This allows the pressure of the fluid at the pump inlet 54 to equalise with the pressure of the fluid at the pump outlet 56 in the event that the member 10 experiences uncontrolled movement causing the brake 22 to be activated, as will be described in more detail below. Specifically, the one-way valve 64 comprises a valve element 68 biased

into abutment with a valve seat 70 by a valve spring 72. While the pressure of the fluid at the pump outlet 56 is greater than the pressure of the fluid at the pump inlet 54, the valve element 68 is maintained against the valve seat 70, to close the conduit 66. If the pressure of the fluid at the pump outlet 56 decreases below the pressure of the fluid at the pump inlet 54, the pressure equalises by the higher fluid pressure on the inlet side lifting the valve element 68 from the seat 70 and allowing fluid to flow through the valve 64.

As noted above, the brake 22 comprises sets of lower and upper slips 26a, 26b. The slips 26a and 26b are energised by a compression spring 76 contained within an annular chamber 78 in the body 14. The slips are normally retained in a retracted configuration, as illustrated in Figure 1. However on release of the slips 26a and 26b, as will be described, the lowermost set of slips 26a is urged upwardly to ride up a ramp 80 to the extended tubing engaging position, and a collar 82 defining the ramp is also pushed upwardly such that an upper ramp 84 acts to extend the upper slips 26b. The lower set of slips 26a are normally fixed relative to the body 14 by radially movable keys or dogs 86 located in windows in the body which engage recesses 89 in a sleeve 90 on which the slips 26a are mounted. The dogs 86 are normally supported by a sleeve 92 of an annular piston 94. When pressure in the piston

chamber 96 reaches the trigger threshold, the piston 94 moves against a compression spring 98, allowing the dogs 86 to move radially inwardly into a groove 88 in the sleeve 92, and out of engagement with the sleeve 90, thus releasing the slips 26a. The spring 98 returns the piston and sleeve 94 and 92 to the neutral position.

In use, a tool string incorporating the device is run through tubing, such as a riser and a cased borehole. Under normal conditions, where the maximum speed of the device 10 through the tubing 16 is known and controlled; the pump 44 will be driven to circulate fluid through the orifice 62, however the fluid pressure at the outlet 56 will not be sufficient to overcome the restraining force provided by the spring 98 acting upon the piston 94. However, if, for example, the wireline on which the tool string is suspended should be severed, the tool string, including the device 10, will accelerate towards its terminal free-fall velocity. This increase in relative velocity between the tubing 16 and the device 10 results in the wheel 32 rotating more quickly, and increasing the fluid circulation rate of the pump 44. This will in turn lead to an increase in the fluid pressure at the outlet 56, and when the fluid pressure reaches a predetermined level, and overcomes the spring 98, the sleeve\piston 92\94 will be moved axially upwards, removing support from the dogs 86, and thus releasing the lower slips 26a. Under the

action of the heavy spring 76, the slips 26a and 26b are extended to engage the tubing 16 and bring the device 10 and the associated tool string to a stop.

5 The device 10 and tool string may then be retrieved using an appropriate fishing tool. On picking up the device 10, the upper slips 26b continue to bite into the tubing 16 as the lower slips 26a disengage from the tubing wall, by upward movement of ramp 80 relative thereto. The lower slips 26a thus move downward, against the action of  
10 the spring 76, and are latched in the retracted position by the dogs 86. The device 10 is then moved downwardly to move the upper slips 26b off the ramp and to the retracted position, against the action of a light spring 100, which ensures that the slips 266 are returned to a "ready"  
15 position as illustrated in Figure 1.

Reference is now made to Figure 3A of the drawings, which is a longitudinal, partially sectional view of part of a device 110 having a restraint mechanism 112 in accordance with another embodiment of the present  
20 invention. As will be described, the restraining mechanism 112 is activated in response to a fluid pressure differential resulting from the movement of the device 110 through fluid filled tubing 114, shown in Figures 3B and 3C, which are partial longitudinal, sectional views of the  
25 part of the device 110 shown in Figure 3A, with a brake of the restraint mechanism shown in retracted and extended

positions, respectively.

The device 110 has a generally cylindrical body 116 which carries a set of slips 118, having ridged faces 119, which co-operate with an axially movable wedge 120. Compression springs 122, 123 urge the slips 118 radially inwardly and urge the wedge 120 to a slip retracted position shown in Figure 3B.

The wedge 120 is coupled to a piston 124 located in a fluid passage 126 defined between inner and outer sleeves of the body 128, 129. A swab cup 130 is provided on the exterior of the body 116 such that fluid within the tubing 114 is directed through a fluid passage inlet 132 formed in the outer sleeve 129. Orifices 134 are provided in the piston 124 such that there is restricted fluid flow through the piston 124, which fluid may then flow from the body 116 through outlets 136 formed in the outer sleeve 129. Thus, as the device 110 and an associated tool string is lowered through the tubing 114, the flow of fluid through the passage 126 creates a pressure differential across the piston 124, the pressure differential depending upon the configuration of the orifices 134, the viscosity of the tubing fluid, and most importantly the relative velocity of the device 110 and the standing fluid in the tubing 114.

The orifices 134 are configured such that, during normal operations, the pressure differential across the piston 124 will not be sufficient to overcome the pre-

loading of the springs 122, 123, such that the slips 118 remain in the retracted position of Figure 3B. However, if for example the device 110 and associated tool string are inadvertently released, and the device 110 falls through  
5 the tubing 114, the increasing relative velocity between the device 110 and the tubing 114, and in particular the standing fluid in the tubing 114, will increase the pressure differential across the piston 124 to the extent that the wedge 120 will be pushed upwardly, to extend the  
10 slips 118 into contact with the adjacent tubing wall 114, bringing the device 110 to a stop. The movement of the wedge 120 is retained by provision of a ratchet mechanism 138. The ratchet mechanism 138 comprises a locking ring 139, carrying ratchet teeth (not shown) on both its  
15 internal and external faces, for engaging corresponding ratchet teeth on an inner face of the wedge 120 and the inner sleeve 128. The locking ring 139 is provided as a sacrificial component, where the internal and external surface ratchet teeth are shearable.

20 Thus, to release the slips 118, the tool 110 is lifted via the inner sleeve 128, which shears the ratchet teeth of the locking ring 139, allowing the slips 118 to retract.

Referring now to Figure 4, which is a longitudinal, partially sectioned view of a member in the form of a  
25 braking device 210, including a restraint mechanism 212 in accordance with an alternative embodiment of the present

invention. Like components of the braking device 210 with the braking device 10 of Figures 1A and 1B share the same reference numerals incremented by 200. The device 210 includes a brake 222 which is substantially identical to  
5 the brake 22 of the device 10, and thus includes slips 226a and 226b which are activated by a spring 276. The lower slip 226a is mounted on a sleeve 290, defining a recess 289 in which a locking dog 286 is engaged, for retaining the lower slips 226a and thus the upper slips 226b in the  
10 retracted position, shown in Figure 4.

The device 210 differs from the device 10 in that it includes an alternative brake activating arrangement in the form of an accelerometer assembly 140. The assembly 140 includes a sensor in the form of an accelerometer 142,  
15 coupled to a microprocessor 144, which is in turn coupled to and controls the activation of a latch in the form of a solenoid latch 221. The accelerometer 142 measures the rate of change of velocity of the device 210 within a borehole or casing and provides a data output to the  
20 microprocessor 144. The microprocessor 144 controls activation of the solenoid latch 221, in turn activating the slips 226a, 226b, only in the event of an uncontrolled movement of the device 210. Such uncontrolled movement causes the rate of change of velocity of the device to  
25 experience a relatively sharp, prolonged increase. To prevent spurious transient readings from causing a false

brake activating output being generated by the microprocessor, data from the accelerometer is measured over a sample time period. This ensures that minor fluctuations do not cause brake activation.

5           The solenoid latch 221 comprises an annular solenoid core 146, surrounded by solenoid coil 148, both disposed in an annular chamber 150 in the body 214 of the device 210. A compression spring 298 is disposed in an upper end of the chamber 150, and acts between an end 152 of the chamber 150  
10           and an upper end 154 of the solenoid core 146, to exert a force upon the solenoid core to normally urge it axially downwardly into the position as shown in Figure 4. In this position, there is no sensor output from the microprocessor 144, and no current passing through the solenoid coil 148.  
15           The solenoid core 146 therefore supports the locking dogs 286 in the position shown, with a shoulder defined by the core 146 resting on an upper end of the coil 148, where the dogs 286 engage in the recesses 289 of the sleeve 290, to retain the slips 226a, 226b in the retracted position.

20           In the event of an uncontrolled fall, such as when a wireline supporting the device 210 is severed, a sensor output is generated and causes current to pass through the solenoid coil 148. This causes the solenoid core 146 to move axially upwardly, against the restoring force of the  
25           spring 298, until an annular the groove 288 in the outer face of the core 146 is axially aligned with the locking

dogs 286. This allows the dogs 286 to move into the groove 288, thus releasing the sleeve 290. The spring 276 then forces the lower slips 226a, and thus subsequently the upper slips 226b, into the extended position, to bring the device 210 to a halt. Electrical power for the operation of the accelerometer 142, microprocessor 144 and the solenoid latch 221 is provided by a battery pack 156 disposed within the body 214 of device 210.

Turning now to Figures 5A and 5B, there are shown longitudinal, partially sectioned views of a braking device 310, having a restraint mechanism 312, in accordance with a further alternative embodiment of the present invention. The restraint mechanism 312 is shown in a retracted position in Figure 5A and an extended position in Figure 5B.

The device 310 comprises an elongate body 314 which is adapted to be run into and through tubing 316 (shown in Figure 5B). The restraint mechanism 312 comprises a brake activating arrangement 318, which control the activation of a brake assembly 322.

The device 310 is shown in Figure 5A with the brake 322 in the retracted position during controlled movement thereof through the tubing. The elongate body 314 includes an upper end cap 158, and is coupled to a wireline 160 by a sprung activating member 162. The member 162 is disposed in an oil-filled cylinder 164 defined by a chamber in the

body 314. The member 162 is axially movable within the cylinder 164 and is sealed thereto at upper and lower ends by O-ring seals 166 and 168, which prevent egress of damping oil from within the cylinder 164. The member 162  
5 also includes a radially outwardly extending shoulder 170 which serves as a damping piston, and a compression spring 172 is mounted in the cylinder 164 surrounding the member 162. The spring 172 acts between an upper end face 174 of the cylinder 164 and the shoulder 170 of the member 162, to  
10 impart a force upon the member 162 in an axially downward direction.

The brake 322 comprises two arms 176 and 178 which are coupled to the body 314 by a pivot 180. The arms 176 and 178 each carry a friction pad brake 182, and are pivotable  
15 between the retracted position of Figure 5A and the extended position of Figure 5B. The arms 176 and 178 are pivotably coupled to a respective arm moving strut 184, 186, which are themselves coupled to a lower end 188 of the member 162, by a pivot 190.

20 When the device 310 is run through tubing 316 in a controlled fashion, supported by the wireline 160, the weight of the device 310, and any tools, devices or the like mounted thereon, compresses the spring 172 between the end face 174 and the shoulder 170 of member 162. A  
25 shoulder 192 of the member 162 serves to transfer the weight of the device 310 to the upper end cap 158.

However, should the device 310 experience uncontrolled movement, such as may occur should be wireline 160 become severed, the member 162 is no longer coupled to the surface by the wireline 160, and thus no longer bears the weight of the device 310. The force exerted upon the shoulder 170 by the compression spring 172 is then sufficient to force the member 162 axially downwardly to the position shown Figure 5B. This causes the distance between the pivots 180 and 190 to be shortened, in turn causing the struts 184 and 186 to pivot about the pivot 190, and levering the arms 176 and 178 about the pivot 180. This causes the brake pads 182 to move radially outwardly into contact with the tubing wall, to bring the device 310 to a controlled stop within the tubing 316.

When it is desired to recover the device 310 to the surface, the tool is recovered simply by engaging and pulling on the length of wireline 160 still attached to the device, such that the spring 172 is again compressed, pulling the member 162 axially upwardly and returning the brake 322 to the retracted position of Figure 5A.

It will be apparent to those of skill in the art that the above-described embodiments provide devices which may be incorporated in tool strings and which may be relied upon to retain the tool string in tubing in the event of a failure of the tubing string support member, or in the event of a tool string being otherwise inadvertently

released. Further, the devices, and any items coupled to the devices, are readily retrievable.

It will further be apparent to those of skill in the art that the above-described embodiments are merely  
5 exemplary of the present invention, and that various modifications and improvements may be made thereto, without departing from the scope of the present invention. For example, the latched slip arrangement of the first described embodiment may be provided in combination with a  
10 fluid flow responsive latch release arrangement, somewhat like that described in the second embodiment. Further, alternative non-mechanical sensor arrangements may be utilised to detect uncontrolled movement. It will also be apparent to those of skill in the art that, rather than  
15 being incorporated in a device for moving through the tubing, the mechanism could be incorporated in the tubing itself and be adapted to extend into the tubing to engage the device, tool string or tool support therein.

CLAIMS

1. A restraint mechanism for restraining a member adapted to be moved axially through tubing, the restraint mechanism comprising:

5 a brake for selectively restraining the member in the tubing; and

brake activating means for activating the brake on sensing a condition indicative of uncontrolled movement of the member.

10 2. A restraint mechanism as claimed in claim 1, wherein the member comprises an elongate body housing the brake and the brake activating means.

3. A restraint mechanism as claimed in either of claims 1 or 2, further comprising a sensor for sensing  
15 uncontrolled movement of the member.

4. A restraint mechanism as claimed in claim 3, wherein the sensor is adapted to provide a continuous output as the member is moved within the tubing, and indicates  
20 uncontrolled movement of the member when the output reaches a predetermined value.

5. A restraint mechanism as claimed in claim 3, wherein

the sensor is adapted to only provide an output on the member experiencing uncontrolled movement.

6. A restraint mechanism as claimed in any preceding claim, wherein the brake is adapted to be moved between a retracted position and an extended position, for  
5 restraining the member in the tubing.

7. A restraint mechanism as claimed in claim 6, wherein the brake is initially retained in the retracted position.

8. A restraint mechanism as claimed in either of claims  
10 6 or 7, wherein the brake is biased towards one of the retracted or extended positions.

9. A restraint mechanism as claimed in any one of claims 6 to 8, wherein the brake is retained in the extended position following activation by the brake activating  
15 means.

10. A restraint mechanism as claimed in any preceding claim, wherein the brake comprises a plurality of circumferentially disposed slips adapted to be moved to an extended position.

20 11. A restraint mechanism as claimed in claim 10, wherein

the slips define a ratchet arrangement to retain the extension of the slips.

12. A restraint mechanism as claimed in any one of claims 3 to 11, wherein the sensor comprises an accelerometer for  
5 sensing the rate of change of velocity of the member.

13. A restraint mechanism as claimed in claim 12, wherein the restraint mechanism further comprises a processor, coupled to the accelerometer, for receiving data concerning the acceleration of the member, and for providing an  
10 appropriate output in the event that the member experiences uncontrolled movement, to activate the brake.

14. A restraint mechanism as claimed in any preceding claim, wherein the brake activating means comprises a solenoid latch.

15. A restraint mechanism as claimed claim 14, wherein the brake comprises a plurality of circumferentially disposed slips which are retained in a retracted position by one or more radially movable locking keys disposed in the member, each key being adapted to engage a portion of a slip, and  
20 being maintained in the retaining position by the solenoid latch.

16. A restraint mechanism as claimed in any preceding claim, wherein the brake activating means comprises one or more extendable members which are adapted to extend in the event of uncontrolled movement of the member.

5 17. A restraint mechanism as claimed in claim 16, wherein the extendable members are pivotably coupled to a body of the member.

10 18. A restraint mechanism as claimed in either of claims 16 or 17, wherein the extendable members are coupled to each other in a scissors configuration.

19. A restraint mechanism as claimed in any one of claims 16 to 18, wherein the extendable members comprise two arms.

15 20. A restraint mechanism as claimed in any one of claims 16 to 19, wherein the member is adapted to be supported from a support member coupled to the brake activating means, and the weight of the member and any associated tools suspended via the brake activating means retains the brake activating means in the retracted position.

20 21. A restraint mechanism as claimed in any one of claims 16 to 20, wherein the brake activating means further comprises an activating member, coupled to the extendable

members, for moving the extendable members between a retracted position and an extended position.

22. A restraint mechanism as claimed in claim 21, wherein the activating member is coupled at a first end to the support member and at a second end to the extendable members.

23. A restraint mechanism as claimed in either of claims 21 or 22, wherein the brake activating means further comprises biasing means, the biasing means serving to bias the activating member and therefore the extendable members towards the extended position.

24. A restraint mechanism as claimed in any one of claims 16 to 23, wherein the brake activating means includes a damper to prevent transient shocks or accelerations of the member from activating the brake.

25. A restraint mechanism as claimed in any one of claims 3 to 11, further comprising a sensor for sensing uncontrolled movement of the member, and wherein the sensor comprises a mechanical sensor assembly.

26. A restraint mechanism as claimed in any one of claims 3 to 11, or claim 25, wherein the sensor comprises a wheel

adapted to engage an inner surface of the tubing and thus sense relative movement between the sensor and the tubing.

27. A restraint mechanism as claimed in claim 26, wherein the wheel is biased into engagement with the tubing by a spring-loaded arm.

28. A restraint mechanism as claimed in any preceding claim, wherein the brake activating means activates the brake in response to fluid pressure.

29. A restraint mechanism as claimed in any one of claims 3 to 12, 26, 27 or 28, further comprising a sensor for sensing uncontrolled movement of the member, and wherein the brake activating means comprises a pump coupled to the sensor.

30. A restraint mechanism as claimed in claim 29, wherein the pump is an axial flow pump coupled to the sensor by a pump drive shaft.

31. A restraint mechanism as claimed in either of claims 29 or 30, wherein the pump has a fluid conduit connected in a closed loop between a pump outlet and a pump inlet, and a restriction therein for restricting fluid flow in the conduit and, in use, maintaining fluid pressure higher at

the outlet than at the inlet.

32. A restraint mechanism as claimed in any one of claims 29 to 31, further comprising a pressure compensator to compensate for variations in hydrostatic pressure as the member is moved through the tubing.

33. A restraint mechanism as claimed in any one of claims 29 to 32, wherein the brake comprises a plurality of circumferentially disposed slips which are initially retained in a retracted position by a lock mechanism, wherein the lock mechanism is fluid pressure activated and comprises an axially movable piston, said piston disposed in communication with an outlet of the pump.

34. A restraint mechanism as claimed in claim 33, wherein the piston is axially movable to selectively release the brake, and is biased towards a brake retaining position.

35. A restraint mechanism as claimed in either of claims 33 or 34, wherein the slips are retained in a retracted position by one or more radially movable locking keys which are adapted to each engage a profile of a portion of a respective slip, said keys being maintained in the retaining position by a part of the piston.

36. A restraint mechanism as claimed in any one of claims 3 to 11, wherein the sensor comprises a pressure sensitive element for detecting pressure differentials resulting from movement of the member through fluid-filled tubing.

5 37. A restraint mechanism as claimed in any preceding claim, wherein the member defines a fluid passage through which fluid flows as the member is moved through the tubing, the passage containing a piston which is responsive to fluid pressure to activate the brake.

10 38. A restraint mechanism as claimed in claim 37, wherein the passage defines a flow restriction, such that the pressure differential across the piston is flow-related.

15 39. A restraint mechanism as claimed in claim 38, wherein the flow restriction is adjustable, to vary a brake activation value.

40. A restraint mechanism as claimed in any one of claims 37 to 39, wherein the brake comprises a plurality of circumferentially disposed slips and wherein the piston is coupled to a cam to urge the slips to an extended position.

20 41. A member adapted to be suspended from a support member in tubing and to be moved axially therein, the member

having a restraint mechanism comprising:

a brake; and

brake activating means for activating the brake in the presence of a condition indicative of uncontrolled movement of the member.

42. A member adapted to be moved axially through tubing, the member having a restraint mechanism comprising:

a sensor for sensing uncontrolled movement of the member;

a brake adapted to be activated to engage the tubing to restrain the member therein; and

brake activating means for activating the brake on receipt of an output from the sensor indicative of uncontrolled movement of the member.

43. A method of restraining a member from uncontrolled movement through tubing, the method comprising the steps of:

providing a brake; and

activating the brake to restrain the member when a condition indicative of uncontrolled movement of the member is experienced.

44. The method of claim 43, further comprising the step of providing a sensor for sensing uncontrolled movement of the member, the sensor being capable of generating a sensor

output indicating an uncontrolled movement of the member,  
to activate the brake.

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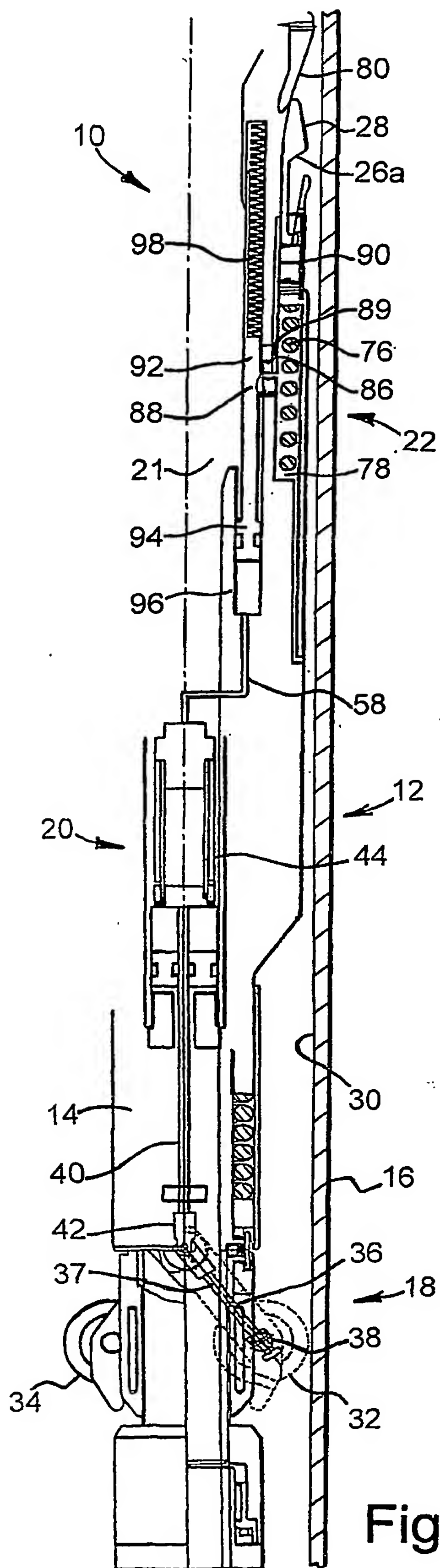


Fig.1A

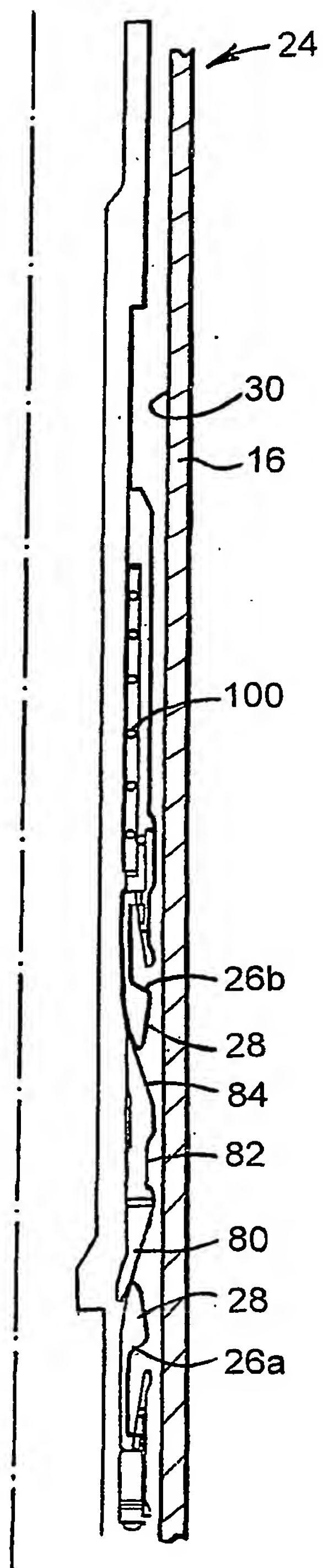


Fig.1B

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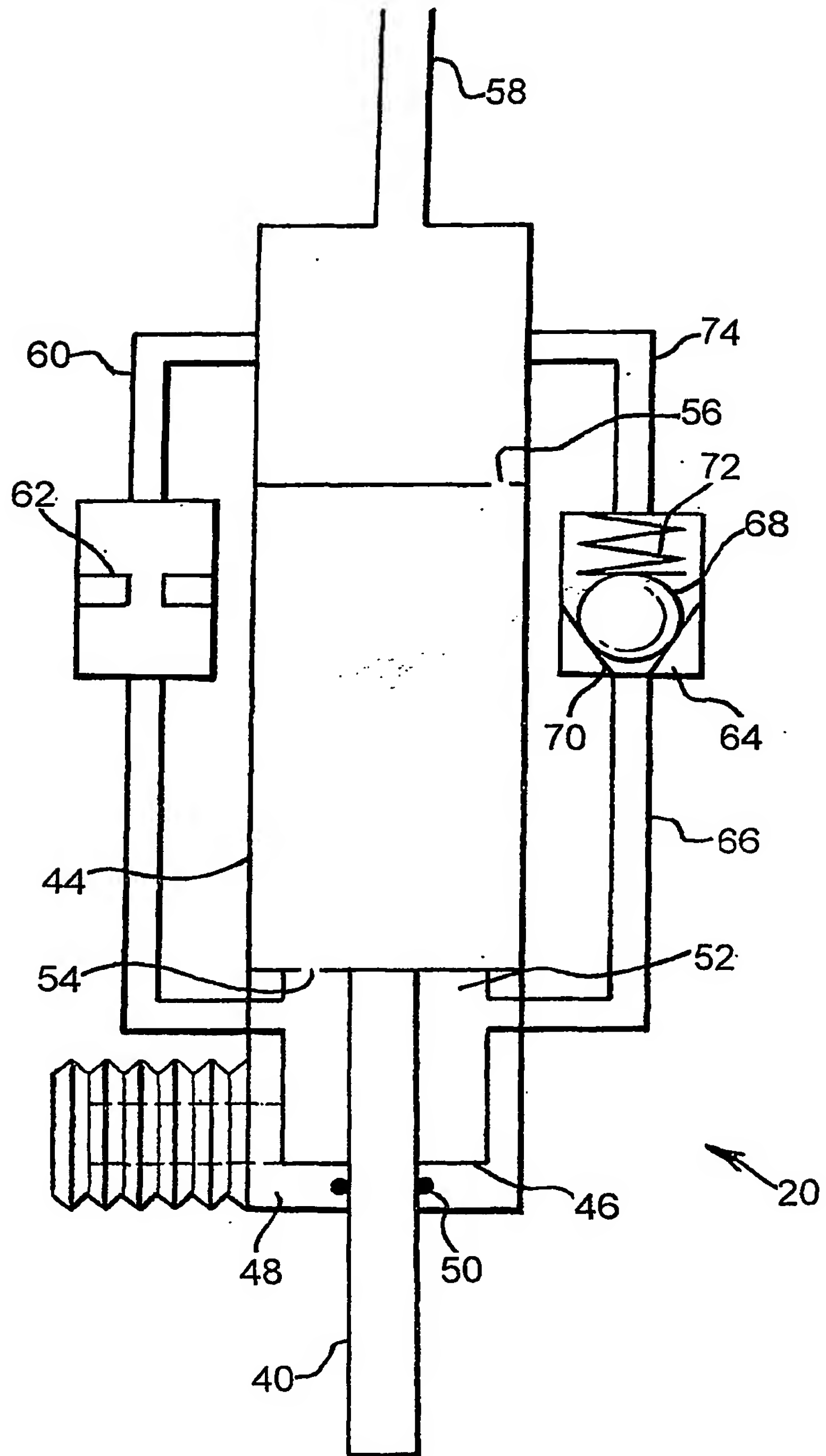
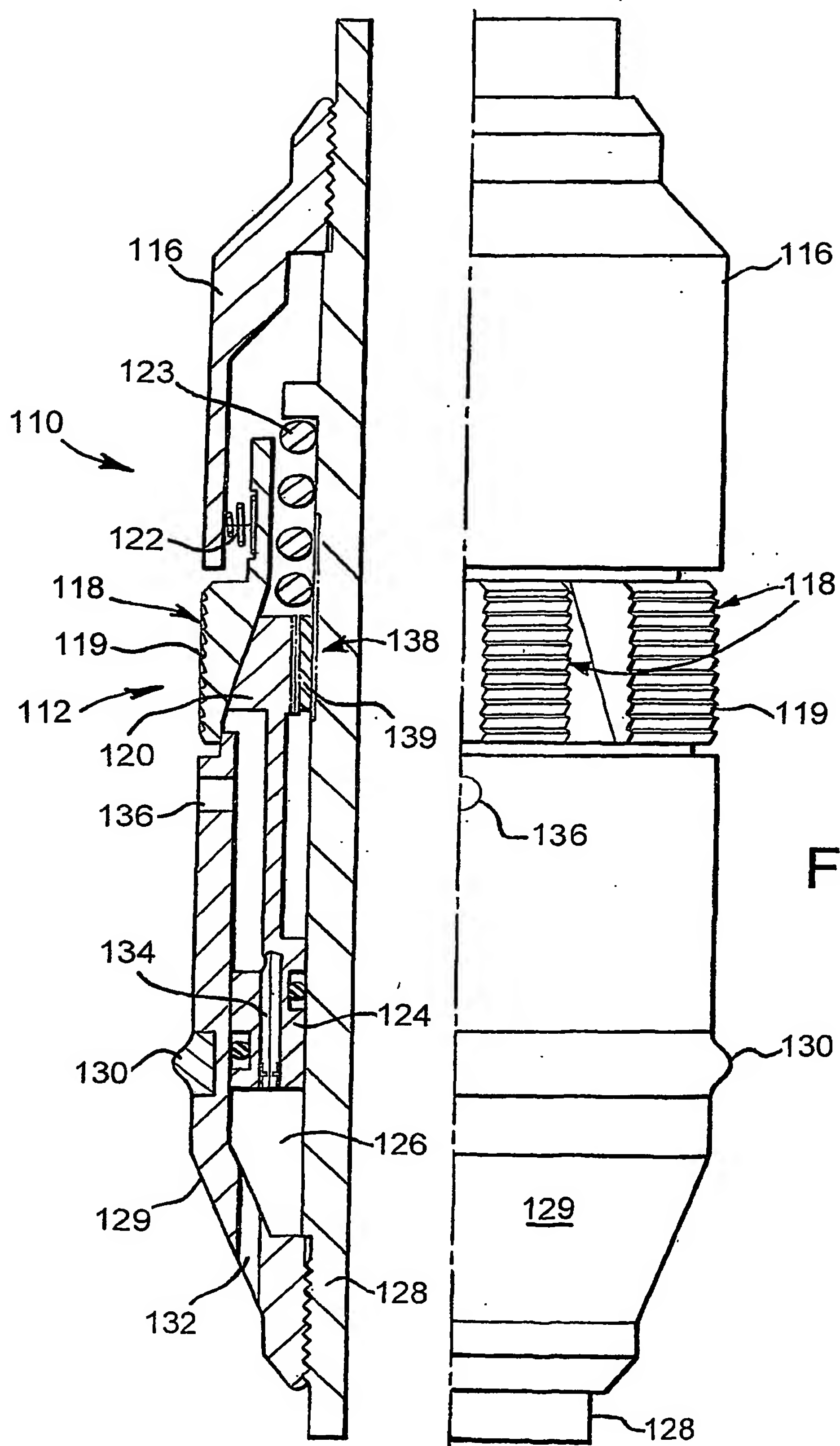


Fig.2

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**Fig.3a**

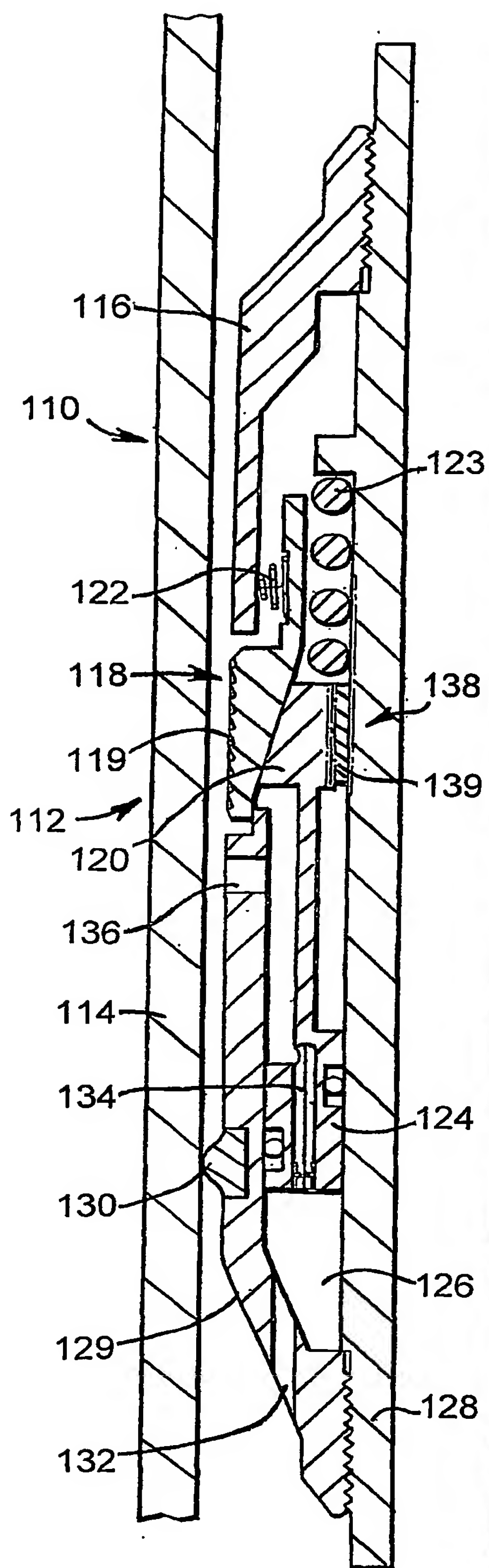


Fig.3B

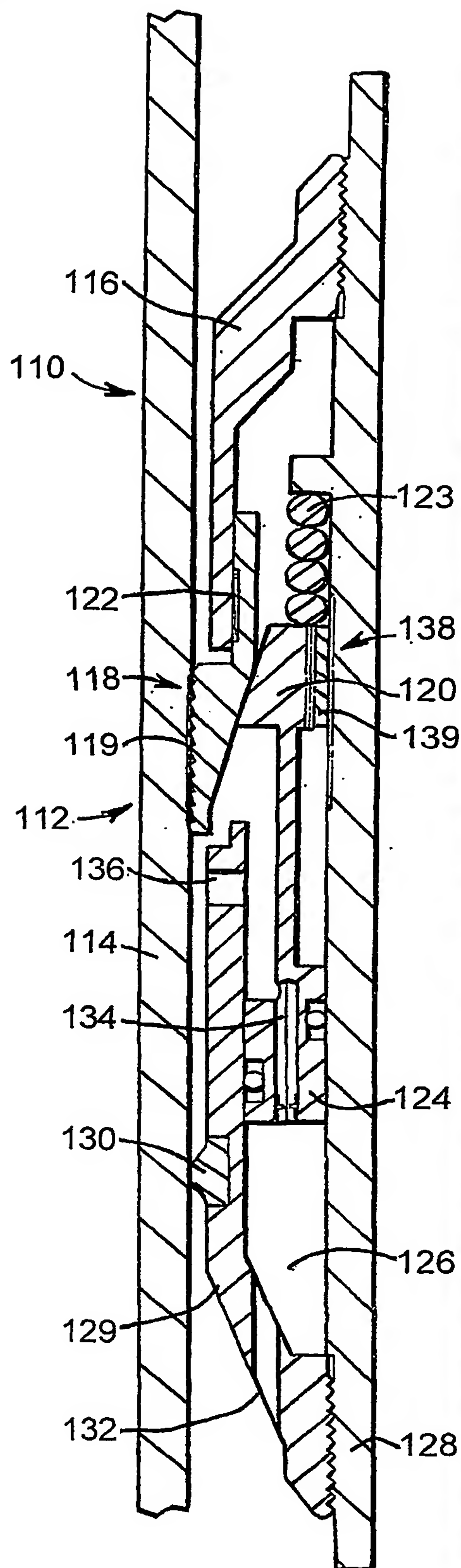


Fig.3C

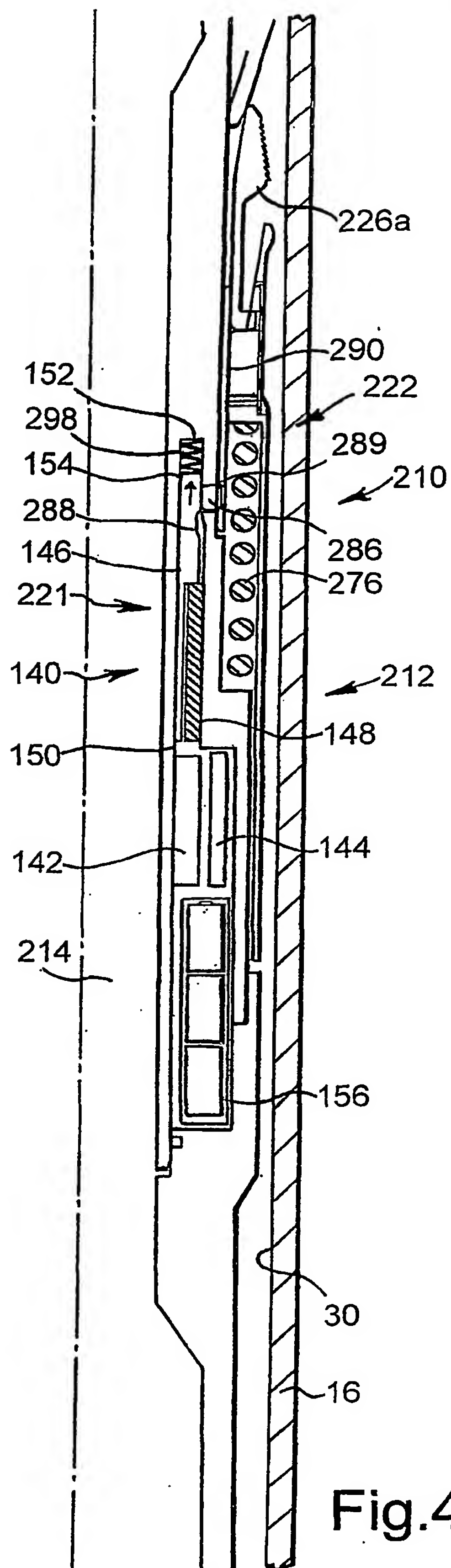


Fig.4A

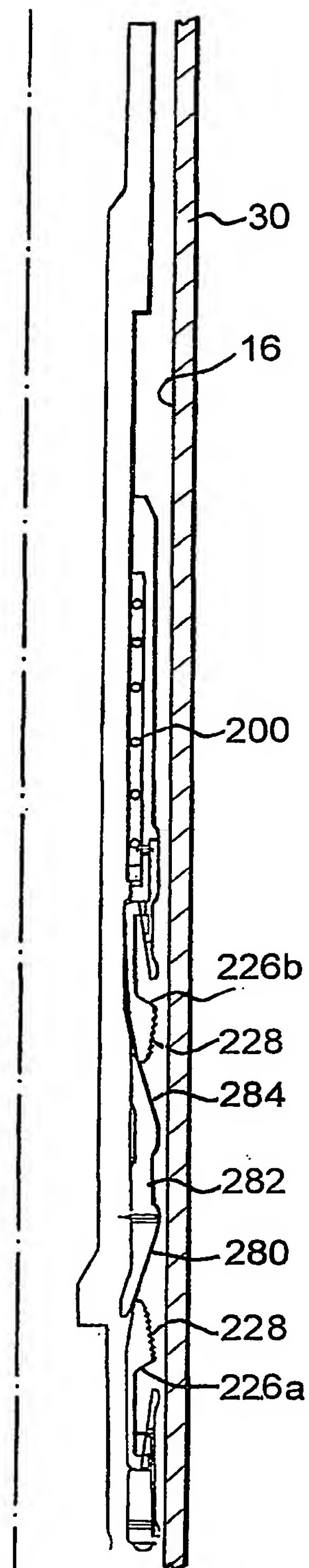


Fig.4B

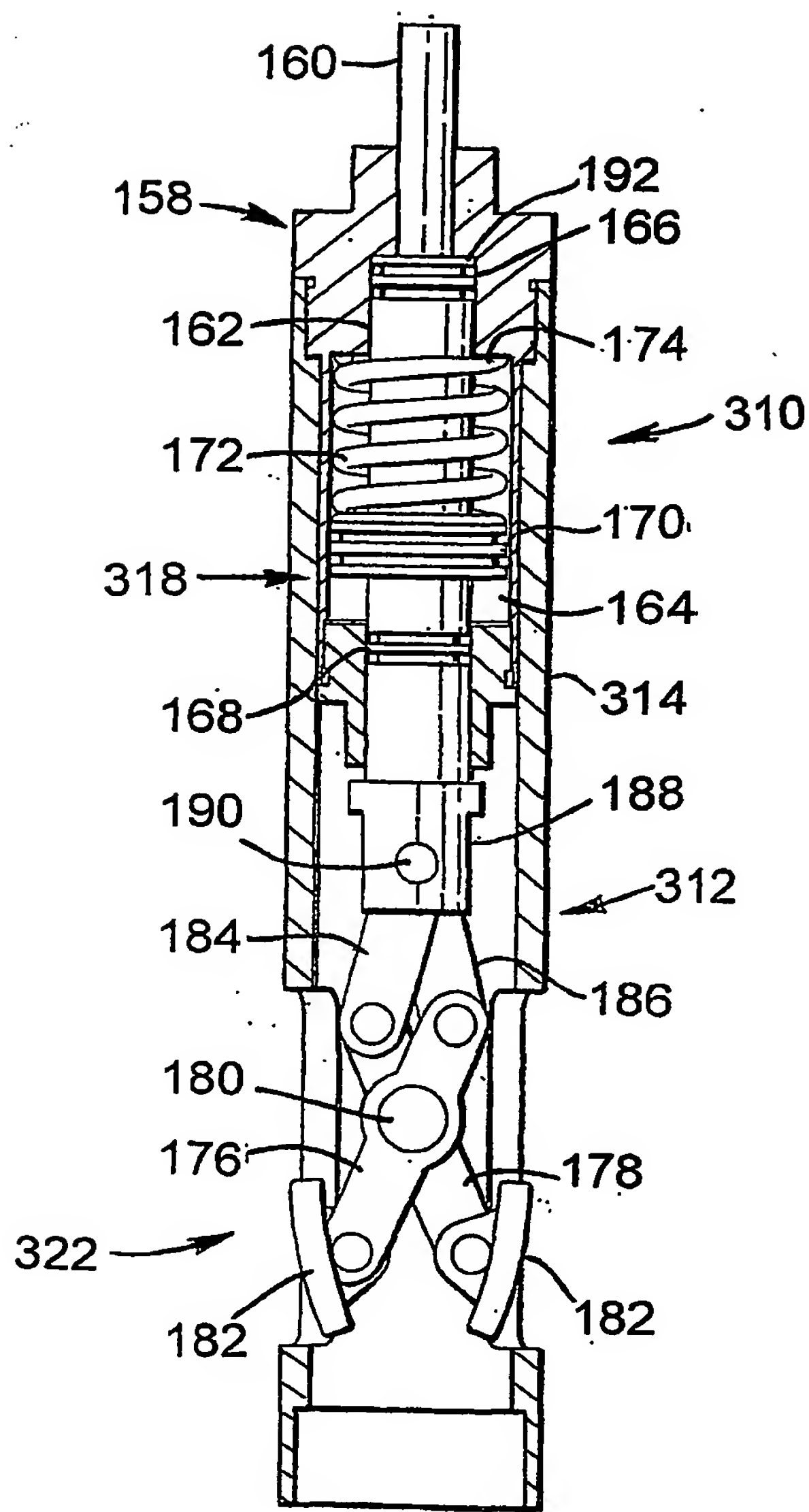


Fig.5A

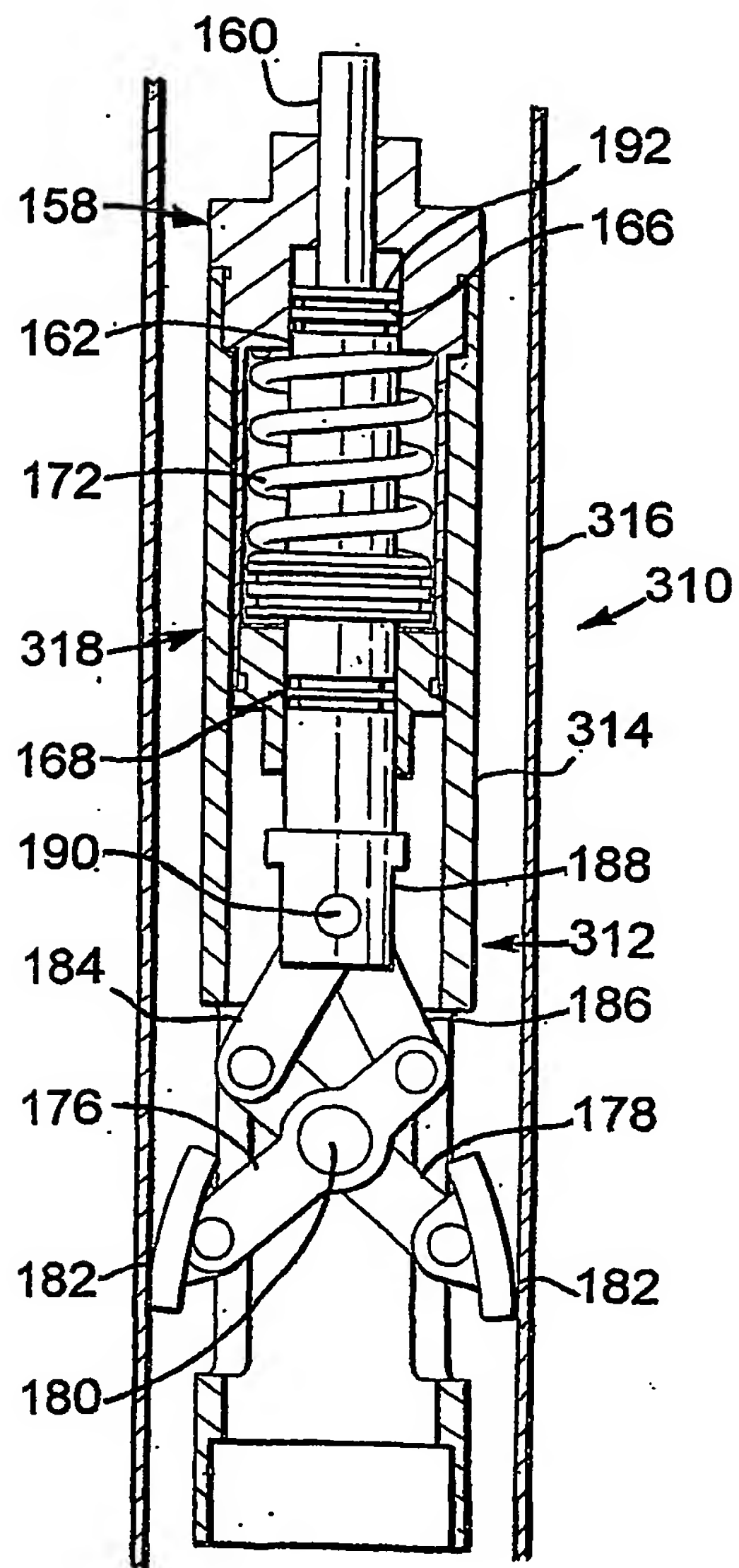


Fig.5B

# INTERNATIONAL SEARCH REPORT

Intern. Application No.  
PCT/GB 01/02368

**A. CLASSIFICATION OF SUBJECT MATTER**  
IPC 7 E21B23/01 E21B23/04

According to International Patent Classification (IPC) or to both national classification and IPC

**B. FIELDS SEARCHED**

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IPC 7 E21B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal

**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 3 572 442 A (TEMPLETON) 30 March 1971 (1971-03-30) column 3, line 34 - line 67 ---	1,2,6, 28,41,43
X	US 3 382 929 A (PLUNK) 14 May 1968 (1968-05-14)  column 3, line 35 - line 53 column 4, line 35 - line 38 ---	1,2,8, 16-23, 28,41,43
X	US 3 294 173 A (HODGES) 27 December 1966 (1966-12-27) column 4, line 41 - line 70 ---	1,2,6,10
X	US 1 667 733 A (LEONARD) 1 May 1928 (1928-05-01) page 2, line 60 - line 114 ---  -/-	1,6,9

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Date of the actual completion of the international search

10 September 2001

Date of mailing of the international search report

17/09/2001

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C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT		
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X	US 3 403 731 A (ARUTUNOFF) 1 October 1968 (1968-10-01) column 3, line 15 - line 37 -----	1, 3, 25-27

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Information on patent family members

Intern Application No  
PCT/GB 01/02368

Patent document cited in search report		Publication date	Patent family member(s)	Publication date
US 3572442	A	30-03-1971	NONE	
US 3382929	A	14-05-1968	NONE	
US 3294173	A	27-12-1966	NONE	
US 1667733	A	01-05-1928	NONE	
US 3403731	A	01-10-1968	NONE	

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